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Skin Conditions in Mask-induced Acne, Acne Vulgaris, and Non-acne Patients with Chronic Mask Usage: A Cross-sectional Comparative Study

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: Chronic skin occlusion during the COVID-19 pandemic has resulted in changes in skin moisture and sebum composition, disrupting the skin's barrier function and leading to an imbalance in skin microflora. This can aggravate acne or lead to the development of new acne lesions, commonly referred to as 'Maskne.'

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Objectives: To investigate differences in skin parameters and microflora among individuals with Maskne, acne vulgaris, and those without acne.
Methods: This study involved three groups, each comprising 33 participants. Skin parameters, such as temperature, pH, microbial flora (assessed by bacterial culture), and pore size (measured through video dermoscopy), were evaluated.
Results: Of the 99 participants, 83% were female and 17% were male, resulting in a sex ratio (F) of 4.8:1. Among the participants, 78% used surgical masks, 20% used N95 masks, and 2% used cloth masks. The prevalence of Maskne and acne was higher in females (34% and 35%, respectively). Maskne showed a higher involvement of the chin (58%) compared to acne vulgaris (36%). Additionally, 46% of the participants had identified risk factors for acne. Maskne patients exhibited significantly lower skin pH, larger cheek skin pore size, and higher cheek temperature compared to acne vulgaris patients. However, there was no significant difference in microbial density between Maskne and acne vulgaris. The study identified one Methicillin-resistant *Staphylococcus aureus* and five *Klebsiella* spp. colonies. Furthermore, 29% of participants reported experiencing other mask-related problems.
Conclusion: Measurement of cheek skin pore size by dermoscopy can serve as a valuable clinical marker for predicting the development of Maskne.

Keywords: Face masks; mask-induced acne; microflora; skin pH; skin pore size; skin temperature.

1. INTRODUCTION

During the COVID-19 pandemic, widespread lifestyle modifications have occurred among the general population, with a significant focus on mask usage to mitigate the risk of SARS-CoV-2 infection, primarily transmitted through aerosols. This necessity, particularly prevalent in the healthcare sector, has led individuals to wear masks for prolonged hours over several months.

The biophysical properties of the skin are influenced by various factors, including humidity and ambient temperature, which can impact skin hydration by increasing transepithelial water loss [1]. High humidity from breath and elevated water loss through the skin can affect skin pores, leading to increased sweating and, consequently, exacerbating acne [2]. Studies on skin occlusion reveal that reduced air circulation over time diminishes skin elasticity. Prolonged usage of personal protective equipment (PPE) like masks and gloves restricts air circulation, elevates humidity, and induces perspiration, resulting in increased temperature. These alterations in skin moisture and sebum composition disrupt the skin's barrier function, creating an imbalance in skin microflora and contributing to various dermatological pathologies [2].

Continuous friction from these products, along with pressure effects and allergic reactions, can damage the skin barrier, leading to breaks [3]. The pandemic has witnessed an increase in acne flare-ups, potentially exacerbated by individuals touching and scratching pimples when removing face masks after extended use [4].

These changes have also predisposed individuals to skin infections, as evidenced by published case reports and series detailing a rise in the incidence and flare-ups of acne vulgaris, contact dermatitis, allergic dermatitis, urticaria, and “mask” tinea [5,6]. Additionally, concerns arise from the repeated reuse of masks, which may become a source of pathogens. Notably, there has been an increased incidence of rhinocerebral mucormycosis in developing countries linked to such practices [7].

Despite these observations, there is a dearth of literature on the chronic usage of face masks and its impact on skin parameters, particularly in tropical countries. Our study aims to address this gap by analyzing these changes in the Indian population.

2. METHODOLOGY

This study was conducted at the Department of Dermatology in collaboration with the Department of Microbiology, following ethical clearance from the Institutional Ethics Committee. The research spanned two months and adhered to the Code of Ethics of the World Medical Association (Declaration of Helsinki of 1975, as revised in 2003) for experiments involving humans. All data were recorded and analyzed anonymously.

In the Outpatient Department (OPD) of the Department of Dermatology and Venereal

Diseases, individuals aged 18 and above, who had been using masks for ≥6 hours/day for ≥6 months, were enrolled in the study. Participants were categorized into three groups: acne vulgaris (AV), mask-induced acne (M), and no acne lesions (NAc). Those who had used any form of medical treatment for acne in the past four weeks were excluded.

Preliminary details, clinical history, and examination of skin lesions were performed after obtaining documented consent. Various parameters were measured at specific points on the face: pH was measured at points A, B, and C (with the arithmetic mean taken); skin pore size was measured at sites B and D using the Dino-Lite DermaScope® video dermoscope and DinoCapture 2.0 software (version 1.5.45.B) under polarized light at 191x magnification; and skin temperature was measured at points B and D. The face was divided into forehead, cheek, nose, and chin areas to determine the distribution of acne lesions.

Skin swabs were taken from specific facial areas, cultured on 5% sheep blood agar and MacConkey agar, and incubated overnight. *Staphylococcus* spp. colonies were checked for DNase activity, and confirmed *Staphylococcus aureus* (S. aureus) and lactose-fermenting colonies from MacConkey agar were further subjected to antibiotic sensitivity testing (AST). Another set of swabs was incubated in Brain-Heart Infusion broth overnight, and the relative microbial density was measured using a photoelectric colorimeter at 600 nm (OD600) and 660 nm (OD660).

The compiled data were entered into Microsoft Excel® v2019, and statistical analysis was performed using IBM® SPSS® Statistics v21. Both parametric and non-parametric tests were applied, with a significance level set at P ≤ 0.05.

3. RESULTS

A total of 33 participants from each group (Maskne [M], Acne Vulgaris [AV], and No Acne Lesions [NAc]), representing 33.33% of the participants in each group, were included in the study. Among the Maskne (M) group, 11 individuals experienced an increase in the number or severity of acne lesions before mask usage, while the remaining 22 developed new lesions as a result of prolonged mask use. Participant profiles are outlined in Table 1.

The majority of participants were females (82.8%, n=82) compared to males (17.2%, n=17), resulting in a Female-to-Male ratio of 4.82:1. Almost all participants were healthcare professionals, with only three exceptions: two students and one software engineer. A higher percentage of females exhibited acne vulgaris (35.37%) and Maskne (34.15%) compared to males (23.35% and 29.41%, respectively), but this difference was not statistically significant (P=0.394).

Comorbidities, detailed in Table 2, were present in 45 participants. The most common comorbidities were a family history of acne (26.26%) and pre-menstrual acne flare-ups (7.07%).

Table 1. Age of participants, average usage of masks per day and duration after which mask was changed

	Lower limit	Upper limit	Mean ± Std. deviation
Age (in years)	18	56	30.52±10.68
The average usage of masks per day (in hours)	6	12	7.69±1.61
Duration after which mask was changed (in days)	0.33	7	1.33±0.94

Table 2. Various risk factors for acne lesions among the participants

Co-morbidities	n	Maskne	Acne vulgaris	No Acne lesions	P
Polycystic Ovarian Syndrome	7(7.07%)	2(6.06%)	4(12.12%)	0(0%)	0.341
Hypertension	5(5.05%)	0(0%)	1(3.03%)	4(12.12%)	0.065
Asthma	4(4.04%)	2(6.06%)	2(6.06%)	0(0%)	0.353
Diabetes mellitus	4(4.04%)	0(0%)	1(3.03%)	3(9.09%)	0.161
Use of anti-epileptics	1(1.01%)	0(0%)	0(0%)	1(3.03%)	0.364

Co-morbidities	n	Maskne	Acne vulgaris	No Acne lesions	P
Hirsutism (without PCOS or confirmation of PCOS)	1(1.01%)	0(0%)	0(0%)	1(3.03%)	0.364
Pre-menstrual flare-up of acne	7(7.07%)	2(6.06%)	5(15.15%)	0(0%)	0.054
Alcoholism	5(5.05%)	1(3.03%)	2(6.06%)	2(6.06%)	0.810
Smoking	3(3.03%)	2(6.06%)	1(3.03%)	0(0%)	0.357
Family History	26(26.26%)	5(15.15%)	11(33.33%)	10(30.30%)	0.199

During the initial year of the COVID-19 pandemic, 97 out of 99 participants used N95 masks. However, as indicated in Table 3, the majority now use different masks at various times, with 77.8% changing their masks at least once daily. The facial distribution and grading of acne lesions are illustrated in Figs. 1 and 2.

Fig. 3 and Table 4 outline the various problems faced by participants due to chronic mask usage. The duration of mask usage beyond 6 hours per day did not correlate with a higher occurrence of mask-related problems (P=0.333). Additionally, there was no significant difference in the occurrence of these problems between the three groups (P=0.396) or based on the type of mask used (P= 0.062). However, the severity of these problems was notably higher with the use of N95 masks.

Table 3. Mask preference among the 3 groups shows no significant difference (P=0.772)

	Type of mask used		
	Surgical mask	N95 mask	Cloth mask
Maskne	27 (81.8%)	5 (15.2%)	1 (3%)
Acne vulgaris	25 (75.8%)	7 (21.2%)	1 (3%)
No lesions	25 (75.8%)	8 (24.2%)	0 (0%)
Total	77 (77.8%)	20 (20.2%)	2 (2%)

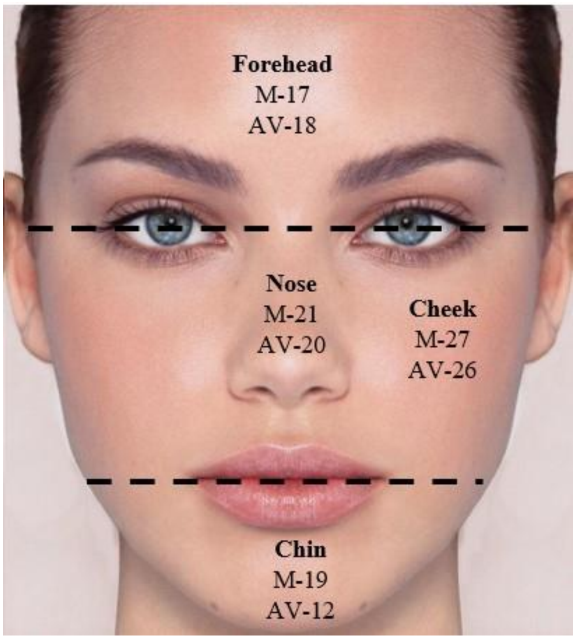

Fig. 1. The distribution (non-exclusive) of acne lesions on the face among the participants. A higher but insignificant (P=0.084) prevalence of chin lesions has been noted in the case of maskne. Insignificant differences in forehead (P=0.805), nose (P=0.800) and cheek (P=0.757) acne lesions was also noted

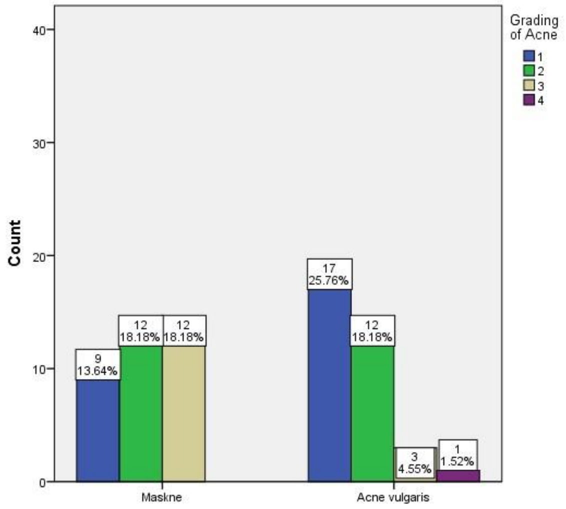

Fig. 2. Grades of acne lesions in maskne and acne vulgaris group (P=0.031)

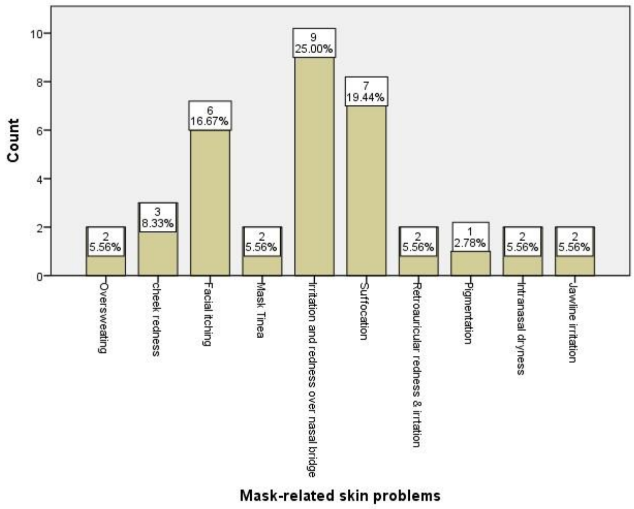

Fig. 3. Various mask-induced problems among the participants(non-exclusive)

Table 4. Frequency of mask-related problems in the three groups and different types of masks. There was no significant difference in their occurrence between the maskne, acne vulgaris and no lesion groups (P=0.396), and the types of masks (P=0.062)

	Mask-related problems
Category	
Maskne	12 (36.4%)
Acne vulgaris	10 (30.3%)
No lesions	7 (21.2%)
Type of mask	
N95 mask	7 (26%)
Surgical mask	20 (35%)
Cloth mask	2 (100%)
Total	29 (29.3%)

Table 5 reveals significantly higher skin pH (P<0.001), cheek skin pore size (P= 0.005), cheek temperature (P=0.026), temperature difference (P=0.002), and skin pore size difference (P<0.001) between the cheek and forehead among the three groups.

No significant correlation was found between the duration of mask usage per day and cheek skin pore size, skin pore size, temperature differences between the cheek and forehead, skin pH, OD660, and OD600.

Culturing results showed skin commensals in all samples, with one sample exhibiting Staphylococcus aureus and five samples exhibiting Klebsiella pneumoniae (Table 6). A nurse's sample revealed Methicillin-resistant Staphylococcus aureus (MRSA) and K. pneumoniae, both of which were sensitive to all tested antibiotics (Tables 6A-1 and 6B-5).

Table 5. pH, temperature at the cheek, temperature at the forehead, Cheek skin pore size, forehead skin pore size, temperature and skin pore size differences between cheek and forehead, CFU on culture, OD600 and OD660 among maskne, acne vulgaris and no acne lesion participants

Characteristics	Maskne	Acne vulgaris	No Acne lesions	P
pH	4.47±0.35	4.79±0.31	5.03±0.35	<0.001
Temperature at cheek (Tc) in ºF	97.66±0.18	97.57±0.22	97.12±1.72	0.026
Temperature at forehead (Tf) in ºF	97.74±0.10	97.75±0.17	97.74±0.13	0.747
Tc-Tf in ºF	-0.079±0.20	-0.18±0.20	-0.62±1.73	0.002
Cheek pore size (Pc) in µm	217.09±82.80	169.41±50.19	208.18±104.63	0.005
Forehead pore size (Pf) in µm	150.18±41.57	157.33±47.28	174.78±69.28	0.122
Pc-Pf in µm	66.91±65.50	12.15±31.59	33.39±72.46	<0.001
Colonies on solid culture media	10247.58±28961.17	9597.82±29082.04	3601.52±17390.28	0.333
OD600	0.36±0.21	0.28±0.19	0.26±0.18	0.122
OD660	0.35±0.20	0.27±0.19	0.26±0.18	0.100
OD660	0.35±0.20	0.27±0.19	0.26±0.18	0.100

Table 6. (A) is the antibiotic susceptibility of Staphylococcus aureus (S. aureus) colonies; 100% were sensitive to clindamycin(DA), 0% to erythromycin(E), 0% to cefoxitin(FOX), 100% to gentamicin(GN), 100% to vancomycin(VA), 100% to linezolid(LZD), 0% to ciprofloxacin(CIP) and 100% to cotrimoxazole(SX-TMP) (B) is the antibiotic susceptibility of gram-negative lactose fermenting bacilli; 100% were sensitive to gentamicin, 100% to ciprofloxacin, 100% to erythromycin, 100% to meropenem(MEM), 80% to ertapenem(ETP), 100% to netilmicin(NET) and 60% to cefotaxime(CTX).[CS=cefoperazone+Sulbactam]; [R= Resistant, I= Intermediate, S= susceptible to given antibiotic]

Table-6-(A)

	Group	Mask type	Colony count	DA	GN	CIP	E	VA	FOX	LZD	SX-TMP
1	NL	N95	5	R	S	R	R	S	R	S	S

Table-6-(B)

	Group	Mask type	Bacteria	Colony count	CTX	CIP	E	CS	MEM	ETP	GN	NET
1	NAc	N95	*Klebsiella*	5	S	S	S	S	S	S	S	S

	Group	Mask type	Bacteria	Colony count	CTX	CIP	E	CS	MEM	ETP	GN	NET
			pneumoninae									
2	AV	Surgical	*K. pneumoninae*	40	S	S	S	S	S	S	S	S
3	M	Surgical	*K. pneumoninae*	5	S	S	S	S	S	S	S	S
4	AV	Surgical	*K. pneumoninae*	50	R	S	S	I	S	S	S	S
5	AV	N95	*K. pneumoninae*	10	R	S	S	S	S	R	S	S

Fig. 4 A: A 21-year-old male medical student presented with an 8-year history of AV (initially grade II) on long term treatment which included on -and-off used of various topical and oral medications; during the COVID-19 pandemic, he used N95 masks predominantly initially for over 10 hours/day, and the acne progressed to grade IV. Severity and number of lesions reduced on shifting to surgical masks later. 18 months ago, he started developing pustules in the moustache, chin and alar crease region, which increased in number and size on prolonged mask usage. Bacterial culture from the lesions revealed Klebsiella pneumoniae (AST- S.no. 1 in Table-6(A)). Pustules over an erythematous base at alar crease and inside nostrils seen (Left image). Polarised video dermoscopy (right image) image of cheek area at 191x magnification demonstrated terminal and vellus hair with patulous openings of pilosebaceous units. Scaling, perifollicular hypopigmentation and interfollicular erythema were noted.

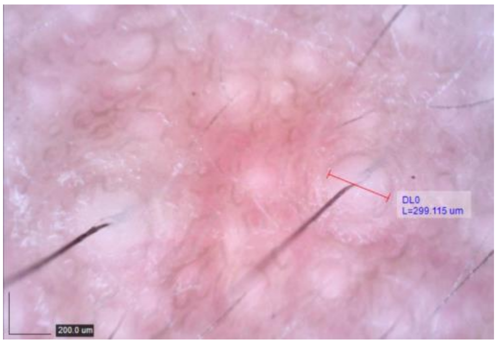

Fig. 4 B: A 21-year-old male medical student presented with an 8-year history of AV (initially grade II) on long term treatment which included on -and-off used of various topical and oral medications; during the COVID-19 pandemic, he used N95 masks predominantly initially for over 10 hours/day, and the acne progressed to grade IV. Severity and number of lesions reduced on shifting to surgical masks later. 18 months ago, he started developing pustules in the moustache, chin and alar crease region, which increased in number and size on prolonged mask usage. Bacterial culture from the lesions revealed Klebsiella pneumoniae (AST- S.no. 1 in Table-6(A)). Pustules over an erythematous base at alar crease and inside nostrils seen (Left image). Polarised video dermoscopy (right image) image of cheek area at 191x magnification demonstrated terminal and vellus hair with patulous openings of pilosebaceous units. Scaling, perifollicular hypopigmentation and interfollicular erythema were noted.

Fig. 4. Depicts a case of maskne complicated with gram-negative folliculitis

4. DISCUSSION

The prolonged use of face masks as a preventive measure against COVID-19 for extended hours has led to various skin changes, predisposing wearers to skin issues [8]. Mask usage for ≥6 hours/day can compromise the skin barrier, resulting in skin diseases such as acne and irritation [9].

During the post-third wave of COVID-19 in India, healthcare workers (HCWs) were the primary users of masks for extended durations. HCWs have a more stringent requirement for personal protection to prevent exposure to SARS-CoV-2 compared to the general population [9]. Varying guidelines on mask usage have led to reduced acceptance among the public [10]. A Korean study indicated that females are more prone to mask-induced skin changes [11].

The shift towards surgical masks could be attributed to the greater comfort they provide compared to respirators, which depend on a tight seal that can lead to increased moisture saturation and stickiness [9,12]. An Indian study found a significant difference in skin changes based on the type of mask used, which was not observed in our study. The number of mask layers, as explored by Dash et al., also did not impact our findings [13]. In our study, 22% of participants changed or washed their masks less than once a day, mainly cloth mask users and N95 mask users, similar to findings from a Belgian study (21%) [1]. This reluctance to change masks may be due to the need to wash cloth masks, unlike disposable surgical masks, and the lower availability and cost of N95 masks. Surprisingly, this was not associated with a significantly higher rate of skin problems, contrary to findings in numerous other studies [14]. Only 10.5% of cloth mask users in a Saudi Arabian study washed their masks after every use [15].

In this study, the preferred mask type was surgical (77.8%), even though participants predominantly wore N95 masks (98%) during the initial pandemic period. A Polish study among youngsters noted predominant cloth (48%) and surgical mask (47%) usage [14], while an Indian study reported 95% N95 mask usage [13], and in the UK (75%) and Saudi Arabia (82.7%), surgical masks were preferred, with more skin problems associated with surgical masks [9,15].

About 29.3% of participants reported mask-related problems, with suffocation (19.44%) and facial irritation & redness (25%) being the most common issues. An Indian study reported such issues in 46% of participants, with itching at the mask contact site and stinging & burning being the most common complaints [13]. A significantly higher incidence of mask-related skin issues was noted with N95 masks in several other studies [7,8], as reported by all our study participants when using N95 masks.

A much higher prevalence of mask-related problems (97%) was reported among Chinese healthcare workers [16]. Contact dermatitis (39.5%) was the most common reaction in another study [17]. A 50% increase in acne in India due to mask usage was observed in a study by Purushotam et al. [18].

In our study, a higher proportion of acne in the maskne group was observed on the chin (57.6%), primarily of grades 2 and 3 (72.7%). Contrasting results in another study suggested that maskne was more prevalent on the cheeks than the chin, with grades 1 and 2 [9]. Additionally, 33.3% of our maskne group had a previous history of acne, compared to 36% in another study [9]. The predominance of chin and cheek acne in the maskne group of our study aligns with the typical O-distribution of maskne [19].

The maskne group exhibited a significantly lower pH, higher cheek temperature, larger cheek skin pore size, and a greater difference in skin pore size between the cheek and forehead compared to the AV and NAc groups. This effect could be attributed to increased sebaceous and sweat output, which predisposes individuals to acne formation and exacerbation in the maskne group [11,20,21]. Mask-wearing also significantly increases skin pore size variation and transepidermal water loss [22]. The temperature difference between the cheek and forehead was significantly higher in the maskne group compared to the AV and NAc groups in this study.

An insignificantly higher density of microflora was observed in the maskne group. Coagulase-negative Staphylococcus spp. was the predominant bacterium cultured. Numerous studies have shown that changes in physical skin parameters, along with genetic factors, lead to microbiome dysbiosis, increased proliferation of Cutibacterium acnes and Malassezia spp., and increased activity of Demodex mites [14,23]. Studies have also noted perioral dermatitis and mask intertrigo due to masks creating another skin interface or fold [24,25]. One isolate of MRSA and five isolates of Gram-negative bacilli were present, with 50% and 16.67% of these isolates resistant to β-lactams (cefoxitin/ceftriaxone) and erythromycin, respectively. These resistance rates were higher than in a Belgian population, where Bacillus, Staphylococcus, and Acinetobacter spp. were commonly isolated (30% for β-lactams and 19% for erythromycin) [1]. Higher resistance rates could be due to a lower number of S. aureus and Gram-negative bacilli and a higher proportion of healthcare workers in our study group. An insignificantly higher difference in bacterial density was noted in the maskne group compared to the AV group.

Although our study is novel in comparing maskne and acne vulgaris among chronic mask users, much research has already been done on maskne, its prevention, and its management. Diagnostic criteria for maskne have been proposed [26,27].

The following behavioral modifications should be implemented: avoiding the multiple reuses of masks (discard respirators and surgical masks after a maximum of 3 days and 4 hours of use) [28,29,30]; practicing hand hygiene; using non-comedogenic skin moisturizers before and after mask usage [29,30]; and intermittent removal of masks whenever feasible [30]. Hand sanitizers should not be used on masks [30]. Various mask materials have been explored to reduce microbial contamination, such as metal-impregnated textiles [27], and to mitigate discomfort and skin problems associated with chronic mask usage [28].

Topical monotherapy with Benzoyl Peroxide, retinoids, and salicylic acid has been associated with irritation under mechanical occlusion and hence is not recommended for maskne. Topical antibiotics or their combination with retinoids or Benzoyl Peroxide in the form of hydrogels are recommended. Oral antibiotics, especially doxycycline, minocycline, and tetracyclines, are recommended due to their anti-inflammatory action. Cotrimoxazole and isotretinoin can also be used [27].

5. LIMITATIONS

This study is a single-center cross-sectional investigation, which limits its ability to provide insights into the long-term changes caused by chronic mask usage. Additionally, the results may not be easily extrapolated to the general population due to the predominance of healthcare professionals in the study group. The role of mask layering was not explicitly examined in our study. Resource constraints also limited the use of more accurate techniques for evaluating various parameters, such as pH strips, skin swabs, and simple aerobic culture due to limitations in anaerobic techniques and the absence of multiplex PCR.

6. CONCLUSION

There is a scarcity of medical literature addressing skin changes resulting from the chronic usage of masks, particularly in tropical countries. This study uncovers notable differences such as a lower pH, larger skin pore size, and higher cheek temperature in patients with mask-induced acne (maskne) compared to those with acne vulgaris (AV). Individuals with a history of previous acne lesions and risk factors such as polycystic ovarian syndrome and pre-menstrual flare-ups were found to have a higher likelihood of developing mask-induced acne. The isolation of Klebsiella spp. was observed in some patients. Notably, N95 and cloth mask users exhibited less frequent mask changes.

Commonly reported mask-related issues included difficulty breathing, redness, and irritation over the nasal bridge, with these problems being more prevalent among N95 mask users. The cheek skin pore size, compared to the forehead skin pore size, emerged as a potential early clinical marker for the development of mask-induced acne (maskne).

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) at this moment declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during writing or editing of manuscripts.

CONSENT

As per international standards or university standards, respondents' written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

As per international standards or university standards written ethical approval has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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